Influence of Soil-Structure Interaction on Motions Recorded at Jensen Filtration Plant during Northridge Earthquake and Aftershocks and its Implications for Nonlinear Site Response.

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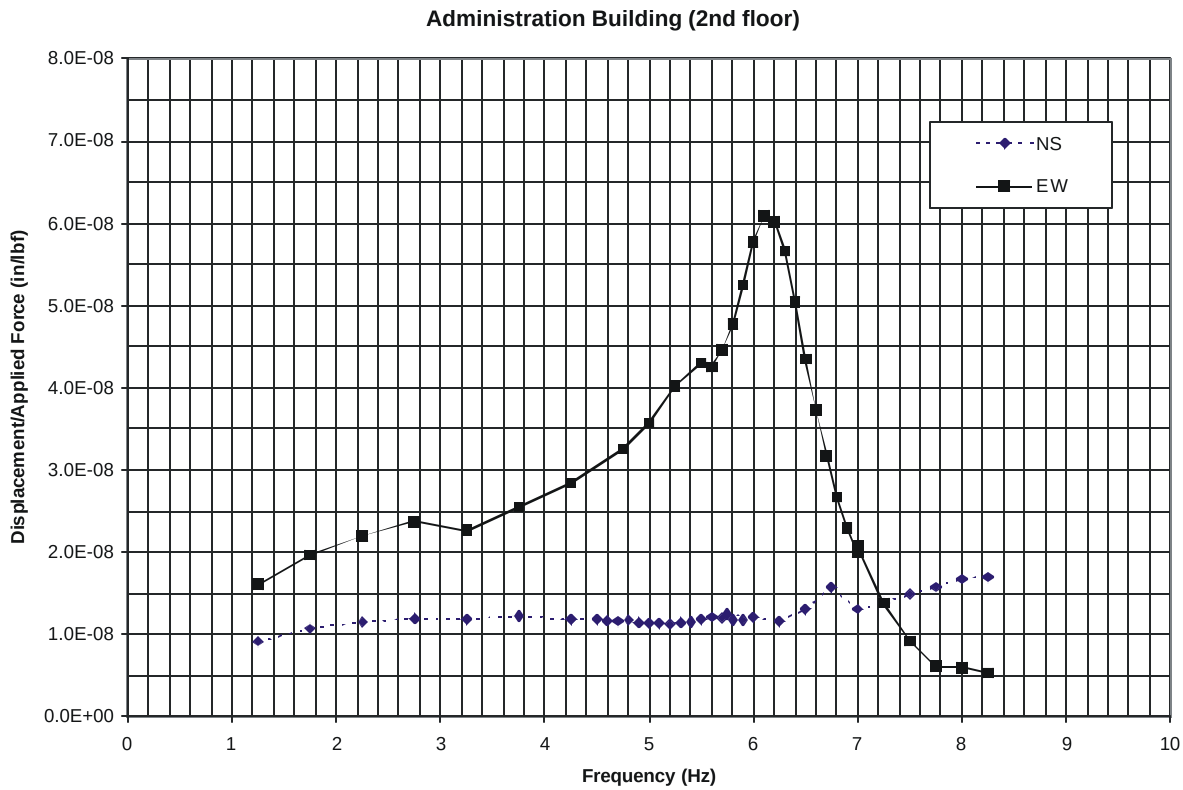
Investigations

Studies during the past year included: (1) reduction of data from the forced vibration tests of the small 1-story Generator building and large 3-story Administration building, (2) computation of frequency-response curves for both principal directions of each building from the vibration-test data, (3) calculation of experimental transfer functions between the motions recorded at the base levels within each building and at nearby free field stations during seven aftershocks, (4) investigation of kinematic soil-structure interaction (SSI) based on earthquake motions recorded at similar types of buildings, and (5) preparation of models for the SSI analysis of both buildings.

Results

The data recorded during the forced vibration tests were used to generate frequency response curves to indicate the natural frequencies any damping ratios in the 1.25 to 8.25 Hz frequency band, which was the limiting frequency range of the eccentric mass shaker used to generate the harmonic vibrations. A representative sample of normalized amplitude-response curves are presented in Figure 1. The EW fundamental frequency (6.2 Hz) was identified for the Administration building. The EW direction corresponds to the shorter dimension of this roughly rectangular building, and this SSI mode involved coupled translation and rocking motion with a modal damping ratio of approximately 8%. The fundamental frequency in the stiffer NS direction for this building is probably just beyond 8.25 Hz based on the amplitude-response curves. At this or any other frequency in the 1.25 – 8.25 Hz band, foundation rocking was not observed during NS harmonic exitation.



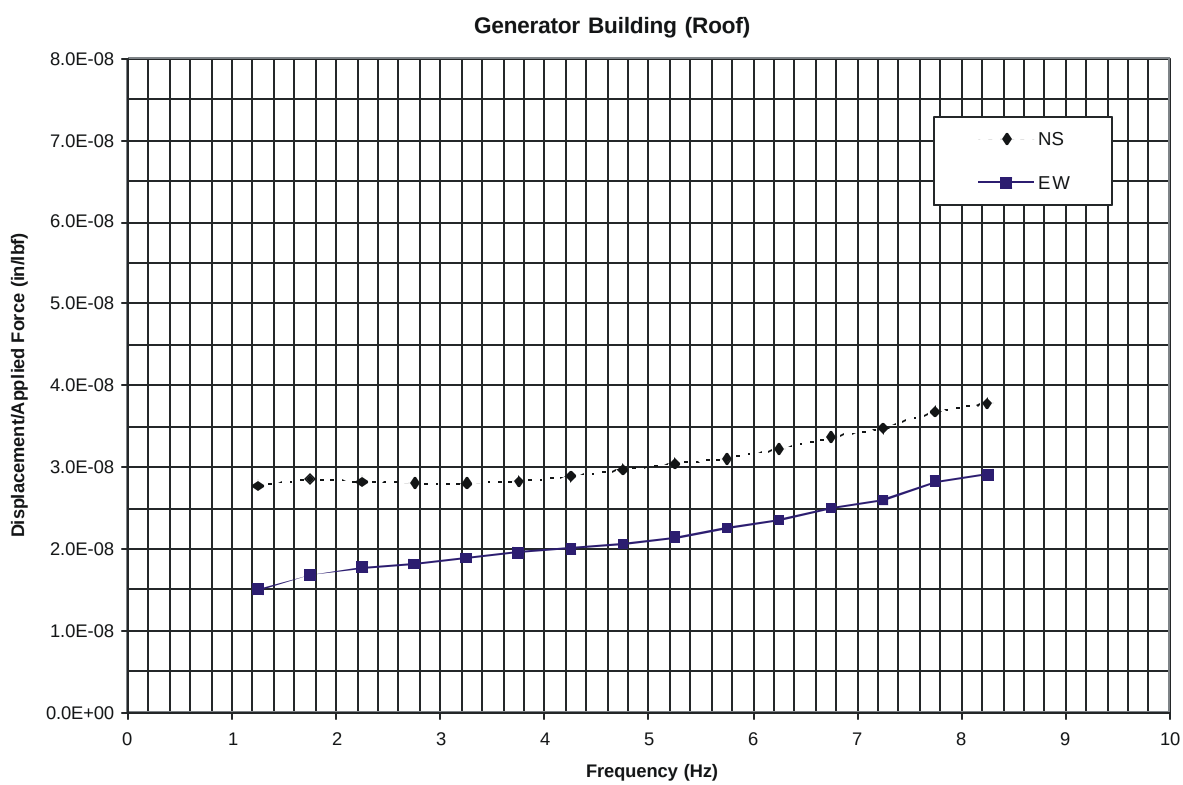


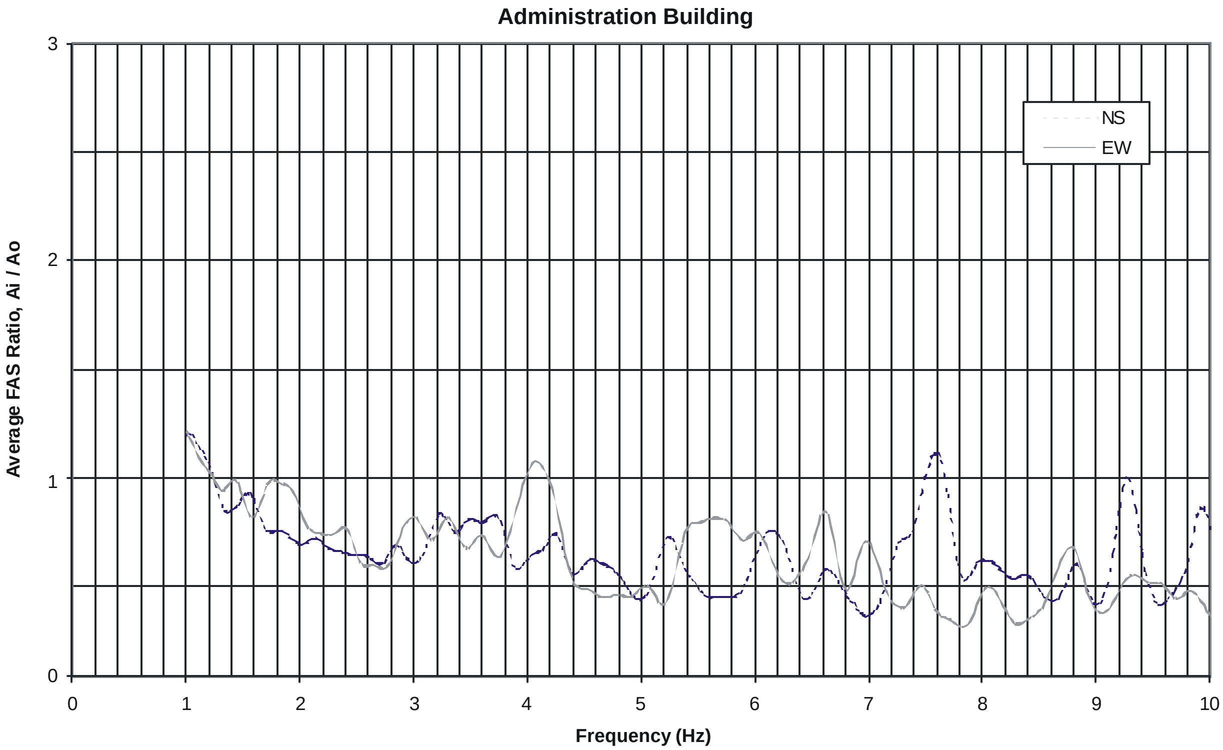
Figure1
Frequency Response Curves From Forced Vibration Tests

Shortly after the Northridge mainshock, the U.S. Geological Survey (USGS) deployed one GEOS accelerograph in the free field near each building and another inside each building next to the strong-motion accelerograph that recorded the main shock. Small motions were recorded on all four instruments during seven aftershocks. The Fourier Amplitude Spectrum (FAS) of each horizontal component was computed from the pairs of records at each building, and the frequency-dependent ratio A_i / A_o was formed, where A_i is the FAS of the component recorded inside the building and A_o is the FAS of the corresponding component recorded outside the building. The A_i , A_o and their ratio was smoothed using the Hanning window, and the 7 sets of ratios were averaged in an attempt to identify certain characteristics of the SSI response, such as natural frequencies and kinematic interaction. The average ratios are plotted in Figure 2.

The average trend of the curves in Figure 2 indicate that there is little or no SSI effects from the Generator building, which is not surprising given the small size of the building and the fact that it is supported on stiff soil. On the other hand, the diminution of motion in the Administration Bldg. relative to the free-field motion is readily apparent. The EW fundamental frequency, which was clearly identified in the vibration test data, is not apparent in this average ratio. The number of accelerograms (7) does not appear to be a sufficient sample size to smooth the presumably random fluctuations observed in the EW curve to clearly reveal the 6.2 Hz fundamental mode. A tentative explanation for the lower motion recorded in the Administration Bldg. is kinematic SSI, which is expected for a building of this size founded on soft soil. Other factors, such as inertial SSI or variable site response, may also be contributing to the result. An inertial SSI model calibrated with the vibration-test data is being developed to determine whether inertial effects can partly explain the A_i / A_o ratio computed for the aftershocks. After this exercise is completed, the focus will turn to the mainshock records. The roles of SSI and nonlinear site effects on the base motions recorded within both buildings during this event will be investigated as an extension of the previous work of Cultrera et al (1999).

Reference

Cultrera, G., Boore, D.M., Joyner, W.B., and C.M. Dietel (1999). Nonlinear soil response in the vicinity of the Van Normal complex following the 1994 Northridge, California, earthquake: Bull. Seism. Soc. Am, 89, 1214-1231.



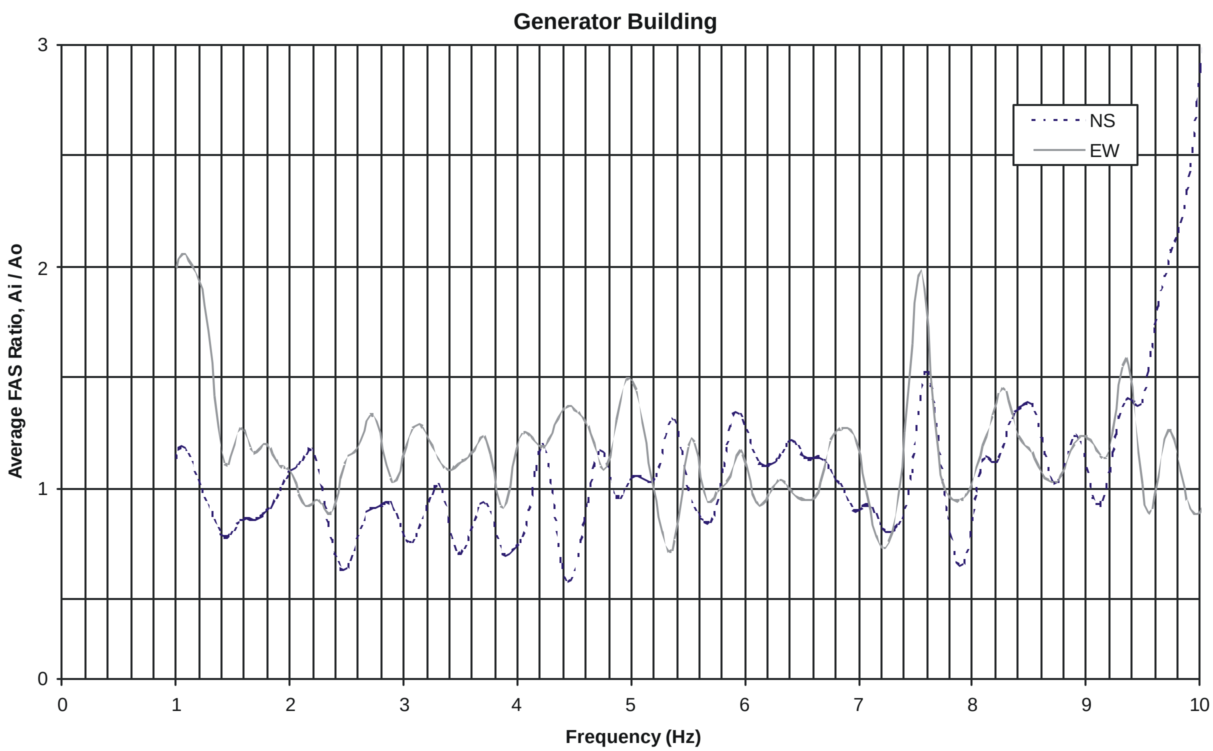


Figure2
Experimental Transfer Functions (Building Base/Free-Field)
From Aftershock Records